

# Holographic Augmented Reality Mirrors for Daily Self-Reflection on the Own Body Image

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Figure 1: A user embodying a generic avatar and observing it in the holographic mirror (adapted from Wolf et al. [20]).

## ABSTRACT

Mirror self-reflection can help us to develop a deeper understanding and appreciation of our body. Due to technological advancements, holographic augmented reality (AR) mirrors can create realistic visualizations of virtual humans that can represent one's appearance in an altered way while remaining in a familiar environment. Further developing those mirrors opens a new field for use in everyday life. In this work, we outline possible future scenarios where

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WS28, CHI '23, April 23–28, 2023, Hamburg, Germany

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AR mirrors can empower individuals to visualize their emotions, thought patterns, and discrepancies related to their physical body and mental body image. Thus, AR mirrors can encourage their self-reflection, promote a positive and healthy relationship with their bodies, or motivate them to take action to improve their well-being.

## KEYWORDS

Augmented reality, virtual reality, virtual human, avatar, holographic mirror, self-reflection, body perception, body image

## ACM Reference Format:

Marie Luisa Fiedler, Erik Wolf, Marc Erich Latoschik, and Carolin Wienrich. 2023. Holographic Augmented Reality Mirrors for Daily Self-Reflection on the Own Body Image. In *Integrating Individual and Social Contexts into Self-Reflection Technologies Workshop (WS28, CHI '23)*, April 23–28, 2023, Hamburg, Germany. ACM, New York, NY, USA, 4 pages.

## 1 INTRODUCTION

Self-reflection on our own body involves observing and analyzing our own physical characteristics, sensations, and experiences. This may include examining thoughts and feelings about our body's appearance and the mental image we have about it. When self-reflecting on our body, observing it in a mirror can be helpful because it shows us our body from an allocentric perspective. Further, looking at our mirror reflection can increase self-compassion, support stress management, and improve emotional resilience [16]. Overall, self-reflection can support us in developing a deeper understanding and appreciation of our body and can help to identify areas where we may want to make changes or improvements, for example, through exercise or other health-related behaviors. However, when we look in a real mirror, we can only observe our current body. With today's technological advances in the development of augmented reality (AR) mirrors, we can go a few steps further to enhance self-reflection processes. We can show the current image but also alter it into all possible past or future body shapes and looks, or even aspects of the body that correspond only to our mental images. Thus, we can view any desired changes to our body right before our eyes in a mirror. Examples can be found in the fashion industry, where AR clothing can augment our whole body for fitting [3], or in social media, where AR face filters can modify our self-expression in real-time. Unfortunately, the impact of these social media AR mirrors can have positive and negative effects on well-being [7]. Research has shown that such virtual appearance modifications can affect body image, cause anxiety and body dysmorphia, and even lead people to undergo cosmetic surgery [13]. Utilizing AR mirrors to encourage individuals to reflect on their bodies and promote positive body image can help to prevent such adverse effects. Thus, investigating whether AR mirrors can serve as a tool to promote self-reflection and improve personal body image is a research field that warrants immediate attention.

### 1.1 Developments in AR Technology Supporting and Augmenting Reflective Practices

The examples above mostly display AR mirrors on handheld displays. However, holographic AR mirror systems based on optical see-through or video see-through head-mounted displays (HMDs) gain in importance, as they are more immersive than handheld displays, providing the advantage of freehand interaction and allowing for a realistic integration of virtual content in a real environment [6, 20]. By wearing such an HMD, the screen does not serve as a mirror, but the real world is rather augmented by a virtual mirror. In this mirror, users can observe their personalized avatar behaving as they do, which is expected to increase self-identification [5]. Nowadays, the generation of personalized photorealistic avatars is possible quickly due to advanced reconstruction methods [1, 2, 17].

The use of avatars and mirror exposures to influence behavior and self-perception has been a hot topic in virtual reality (VR) research for some time, where the benefits of VR-related qualia have been exploited, such as the system's high immersion, sense of embodiment, and presence [4, 15, 18, 19, 21]. The sense of embodiment describes the sense of owning, controlling, and being inside a virtual body or body parts and is divided into virtual body ownership, agency, and self-location [9]. Presence, defined as the

"feeling of being in a place", depends on application, system, and individual-related factors, ultimately leading to "the perceived realness of a mediated or virtual experience" [10, 14]. The concepts are now spilling over into AR research, and many of them that have already been demonstrated in VR, such as the emerging sense of embodiment when viewing an avatar in a virtual mirror, could be successfully demonstrated as well in AR [6, 12, 19, 20]. This can be beneficial because AR provides several advantages over VR. While VR eliminates the visual perception of the real environment, AR breaks the isolation of users in the virtual environment. AR experiences allow users to remain in a real, and perhaps familiar, environment while still being confronted with a realistic-looking modifiable self-replica. Moreover, they can directly refer to the experience of their physical body and draw comparisons between their virtual and physical body. Furthermore, interactions between users and non-immersed persons are feasible, as they remain visible to the users and within their reach. These factors offer a significant advantage to AR to include the social context in the reflection processes. This can be important in psychological therapy settings or integrating bodily reflections in daily life situations.

Overall, based on the advantages mentioned above of AR and the existing research insights that virtual embodied representation can influence the user's self-perception not only in VR but also in AR, it seems reasonable to use holographic AR mirrors as a medium for self-perception and self-reflection of one's body. The goal of our work is to outline potential scenarios of how AR mirrors can enable individuals to visualize their thought patterns and discrepancies related to their physical bodies and mental body image in order to stimulate the individual's self-reflection to motivate them to take action to improve or regain a healthy relationship with their bodies. Thus, the present position paper contributes to the question, what are the potentials and risks of this new technology for body self-reflection?

## 2 HOLOGRAPHIC AR MIRRORS FOR BODY IMAGE SELF-REFLECTION

Holographic AR mirror exposures allow users to engage in immersive self-reflection about their body, desired body, and mental body image. We will describe possible scenarios for using this technology in different situations from the perspective of potential users to increase vividness. Each of the following three subsections takes up one aspect of the advantages of holographic AR mirrors, explains it briefly, and outlines future scenarios for use in everyday life.

### 2.1 The Own Body in Different Body Shapes

In a holographic AR mirror, the users can observe the reflection of their virtual self-replica, which resembles them in appearance and imitates their movements in real-time. While it is usually only possible to view one's body in its current form and appearance when looking into a (real) mirror, the virtual mirror allows changing the own virtual reflection in various ways, as Pete explains:

I have been going to the gym regularly for a few weeks now and have been seeing a gradual increase in my muscle mass. Once per week, in a training session, I use the gym's

advanced holographic AR mirror to track my progress over time visually. This is possible by regularly creating personalized, photorealistic avatars of my current physique. I observe these in front of the virtual mirror and observe my workout progress up close on all my avatars. This gives me additional motivation to follow my path to muscle growth.

## 2.2 Making Comparisons with the Real Body

AR enables users to remain in the familiar environment, allowing for interaction with real objects while exposed. This technology can be used not only in professional places, such as the gym, but also in everyday life at home. In addition to displaying a body with different muscle proportions, as in the first scenario, the virtual mirror can also show one's own body with varying levels of fat, as Loraine in the following scenario describes:

Currently, I am in the process of losing body weight. Through my holographic AR mirror at home, I can send my mirror image on a time journey and look at my progress. I can have my mirror image rapidly regain the body weight I have already lost and show me my previous weight loss success directly in front of my eyes. It is difficult to imagine my body with a certain body weight, but it is easier to visualize my ideal body using the mirror. I start to modify my virtual mirror image so that it matches my ideal body image. Now I take a look in a real mirror next to me. The simultaneous observation in the virtual mirror and in the real mirror allows me to draw direct comparisons between my ideal and my current body, and I notice these bodies are not so different anymore.

Nevertheless, using holographic AR mirrors in everyday life at home can be potentially dangerous for certain user groups, such as individuals with anorexia. The mirrors could further distort their body image by showing an idealized, unhealthy image of themselves, ultimately reinforcing their desire to achieve that image, as Olivia describes:

My goal is to be as slim as the idols on the internet. My holographic AR mirror helps me track my progress toward my weight loss goals. As I stand in front of the mirror, I see a virtual representation of myself. I am shocked by how thin I look, but I am also thrilled by my progress. I begin to spend more and more time in front of the mirror, adjusting my virtual body to make it even thinner. I become obsessed with the idea of achieving an unrealistic and unhealthy weight. My family and friends express concern for my well-being, but I think that I am simply pursuing my goals.

Such a potential adverse effect of daily use of holographic AR mirrors, similar to the described (mis-)use of AR facial filters, must be considered. It is important to reduce the risk of misuse, especially for vulnerable groups such as anorexics. For example, users should

be educated about the potential risks of misuse. Furthermore, time-limited and monitored use by healthcare professionals or family members should be recommended to vulnerable users.

## 2.3 Involving Real People

By keeping the real environment visible when using a holographic AR mirror, it allows for the integration of non-immersed people, unlike VR. This feature is especially valuable in healthcare, as it offers many new possibilities for therapy or plastic surgery. The presented technology can support the expectation management of a plastic surgeon by allowing the patient to examine the physical changes caused by the operation in advance on their own body in the holographic AR mirror, such as Jim, the next scenario narrates:

Massive excess skin is a condition that occurs when patients experience significant weight loss, resulting in disfiguring, oversized skin flaps over the body. As a plastic surgeon, I specialize in removing these skin flaps. Unfortunately, my patients often have unrealistic expectations of the results of the flap removal surgery. I use an AR mirror to show my patients the expected result directly on their embodied personalized avatar before the operation to manage my patients' expectations. This helps to keep their expectations realistic and ensures that they do not experience disappointment after surgery. Instead, they emerge with increased self-confidence and a healthy body shape.

Another future application in the clinical setting is the treatment of anorexia [11]. One of the most significant challenges in treating anorexia is helping patients to develop a positive body image. A holographic AR mirror can be a powerful tool during therapy by allowing patients, with the support of the therapist, to see themselves in a new, more positive light, as Olivia, who finally entered therapy to treat her anorexia, demonstrates in the following scenario:

The use of my holographic AR mirror at home made my anorexia worse. Fortunately, I realize that I need professional help, and I began treatment, which involves extensive conversations with my therapist, as well as reflecting on my current and desired body. My therapist also uses an AR mirror to help me change my self-reflection toward my own body. While observing my virtual self, I can adjust my virtual body to show different body sizes, shapes, and healthy weights to see my body more positively. Additionally, the mirror tracks changes in my body over time as I receive treatment. By comparing my current virtual body to my previous ones, I can witness my progress, which increases my confidence in my ability to overcome my eating disorder, improve my self-esteem, and reduce my negative self-image. Initially, seeing myself with more body weight was challenging, but my therapist was visible to me and supportive throughout all AR mirror exposures.

### 3 CONCLUSION

Holographic AR mirrors offer numerous benefits by allowing users to confront themselves with a virtual self. While remaining in the real environment, users can observe and modify their virtual body to reflect on different sizes, shapes, and healthy weights to support a positive self-perception. Additionally, the mirrors can visualize changes in the body over time, helping users gain confidence in their ability to make progress toward a healthier body image. Furthermore, AR enables comparisons with the real body and interaction with non-immersed persons. This allows for self-reflection within a social context by providing social support while observing the own body in a holographic AR mirror. This support can be especially beneficial for individuals undergoing therapy for body perception disturbances in eating or body weight disorders. The therapist remains within the user's visual reach while users can receive support during exposure, promoting positive changes in body image.

In the past, extensive lab equipment was required to create photorealistic personalized avatars and to render them on a holographic AR mirror mimicking the user's movements in real-time. Due to today's technology, the generation of a personalized photorealistic avatar is quickly possible just using a smartphone [17], and full-body tracking methods are available that do not require additional trackers on the body, which decreases setup complexity and expands the practical application in different environments [8]. Therefore, while it was mainly possible to use holographic AR mirrors in research laboratories or well-equipped facilities, the technology has become more accessible, allowing use in areas without specialized laboratories, public spaces, and even at home, making it possible for individuals to use the technology wherever needed.

Overall, holographic AR mirrors can be used in various settings, including medical and cosmetic practices, or for daily self-reflection at home. We described some future scenarios in this work that allow individuals to see how they would look in different body shapes or after undergoing various procedures. This can help them make more informed and reflective decisions about their body or see it more positively. Holographic AR mirrors provide an innovative and potentially effective tool for improving body image and self-reflection, and we expect to see more widespread use in various settings. However, similar to AR face filters commonly found in social media, holographic AR mirrors also risk reinforcing one's self-optimization. Thus, the use of holographic AR mirrors can easily lead to misuse, particularly if vulnerable groups use them unsupervised at home, as illustrated by one scenario, leading to the same negative consequences for individuals as AR face filters, such as body image concerns, anxiety, body dysmorphia, and even a desire for cosmetic surgery. As such, the field of human-computer interaction needs to design these technologies to encourage self-reflection within a social context.

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